

North Cascades - NPS Stream Biomonitoring Program: Predictive Model Development



Plecoptera
Chloroperlidae: *Sweltsa* sp.



Trichoptera
Limnephilidae: *Ecclisomyia* sp.



Ephemeroptera
Heptageniidae: *Epeorus longimanus*

NOCA STREAM BIOMONITORING PILOT PROJECT OBJECTIVES

- Develop the framework and standards necessary for implementation of a BMI biomonitoring program for streams within NOCA and adjacent USFS lands.
- Evaluate and compare the sensitivity of both multivariate and multimetric approaches in detecting human disturbance.
- Define and document baseline conditions concerning biological integrity of streams in NOCA and adjacent USFS lands.

Predictive Model Development

- Reference site and test site screening and selection.
- Collection of BMI and Environmental Attribute data.
- Development of BMI reference site groups.
- MDFA – Matching Envir. Attribute data with BMI site groups.
- Calculation of O/E (Observed/Expected taxa ratio).
- Model Evaluation and Test Site Assessment

UK and Australia

- Wright, Moss *et al.* 1984
- Moss, Furse *et al.* 1987
- Wright 1995
- Simpson, Norris *et al.* 1997

Pacific Northwest

- Hawkins, Ostermiller
Utah State Univ.
www.cnr.usu.edu/wmc
- Canale, Oregon DEQ
- Reynoldson, Env. Can.

Sampling Effort

- **Total reaches = 158**
- **Reference sites (Dist. Score <26) = 96**
 - Model development = 79
 - QA/QC = 17
- **Test sites = 62**

Composite Sample Replicates

- **Within Reach (three replicates/reach) = 7 reference and 7 test sites**
- **Between Years (2 years) = 17 reference and 9 test sites**

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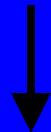
BMI Site Group Classification

BMI data reduction

237 taxa - -> all composite samples (n=213)



190 taxa - -> 500 count subsample (n=213)

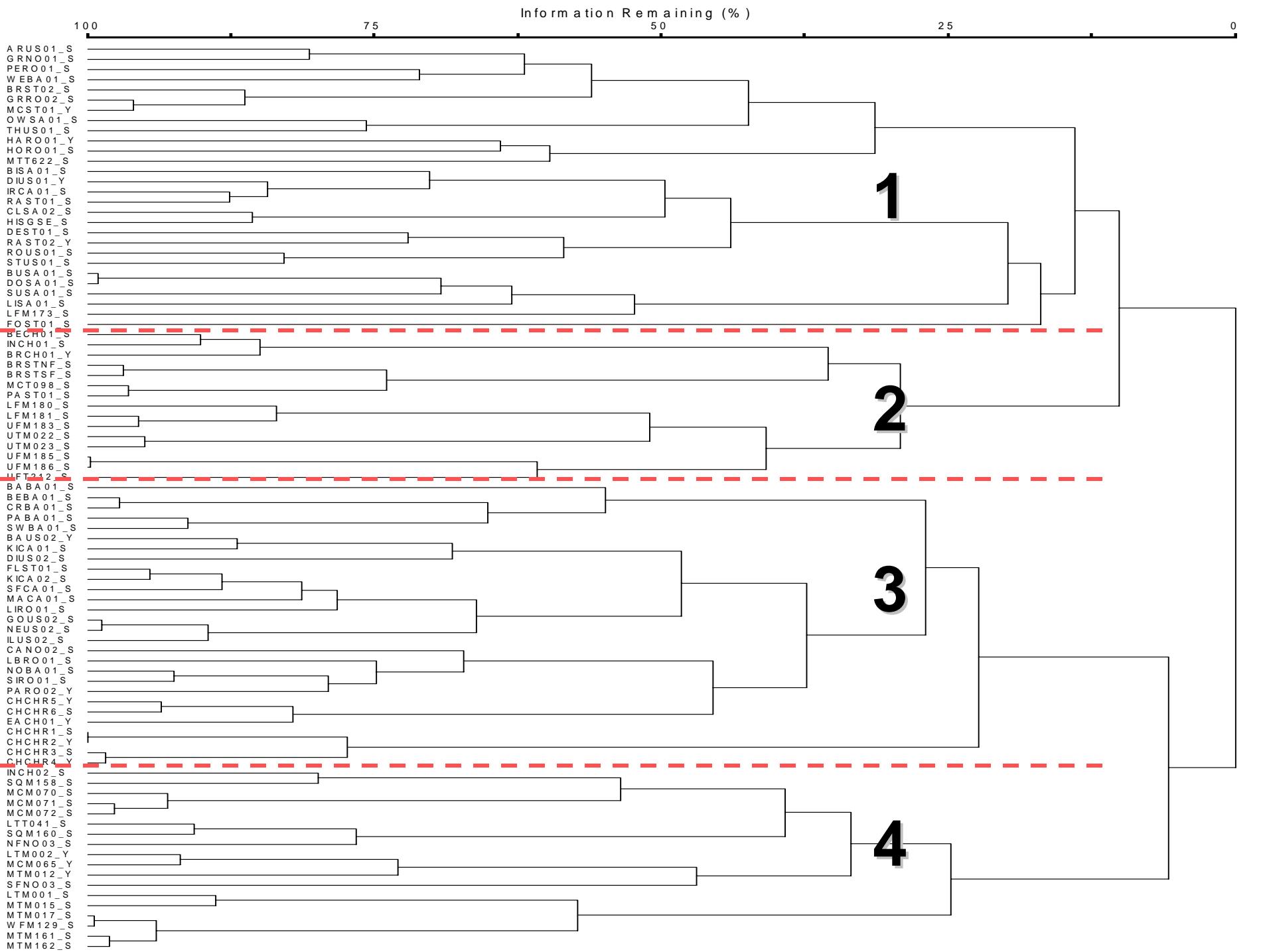


92 taxa - - -> Reference sites-500 ct. (n=96)

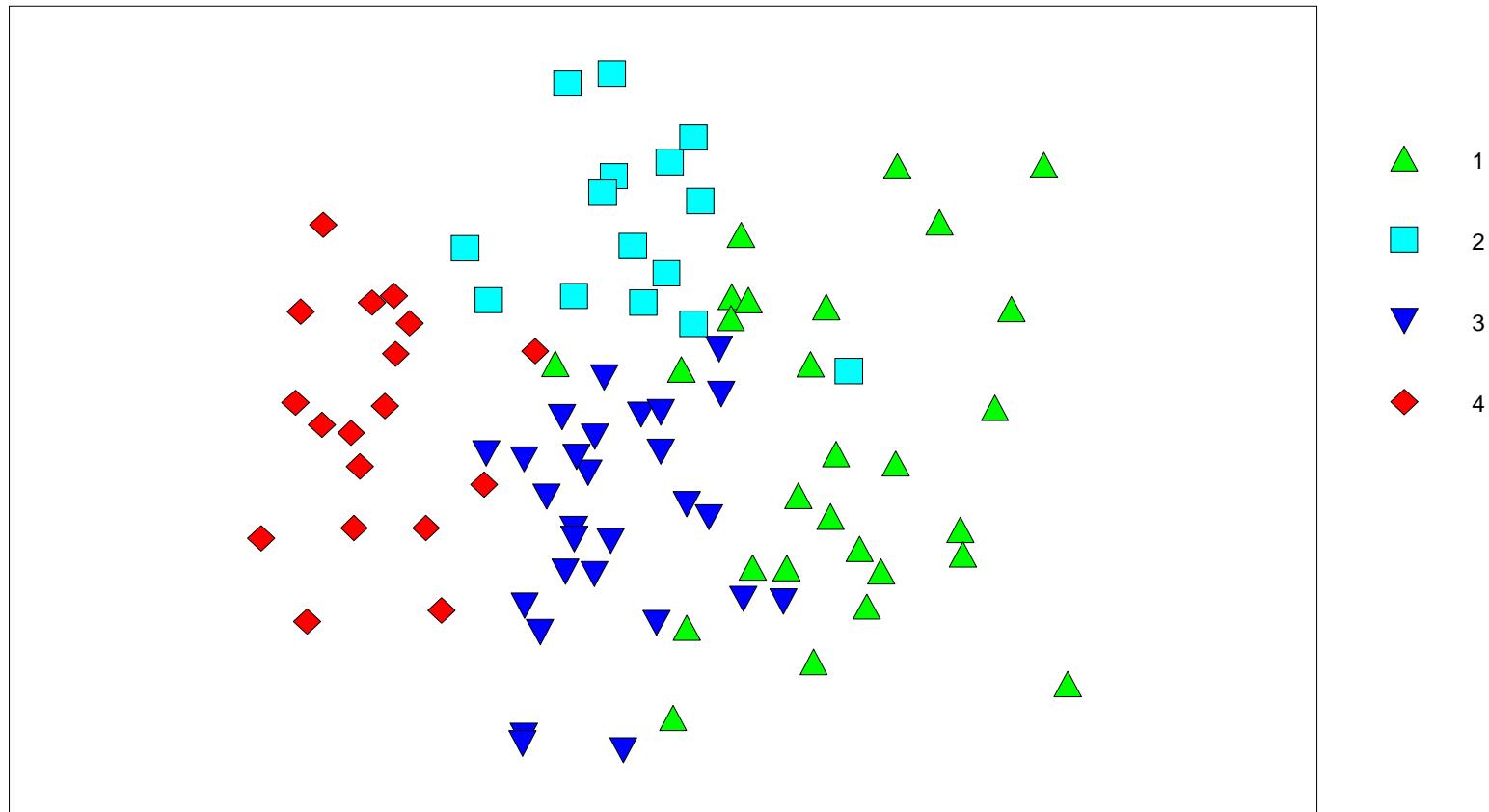


and dropped taxa found at < 5%
of the sites.

Cluster analysis/TWINSPAN



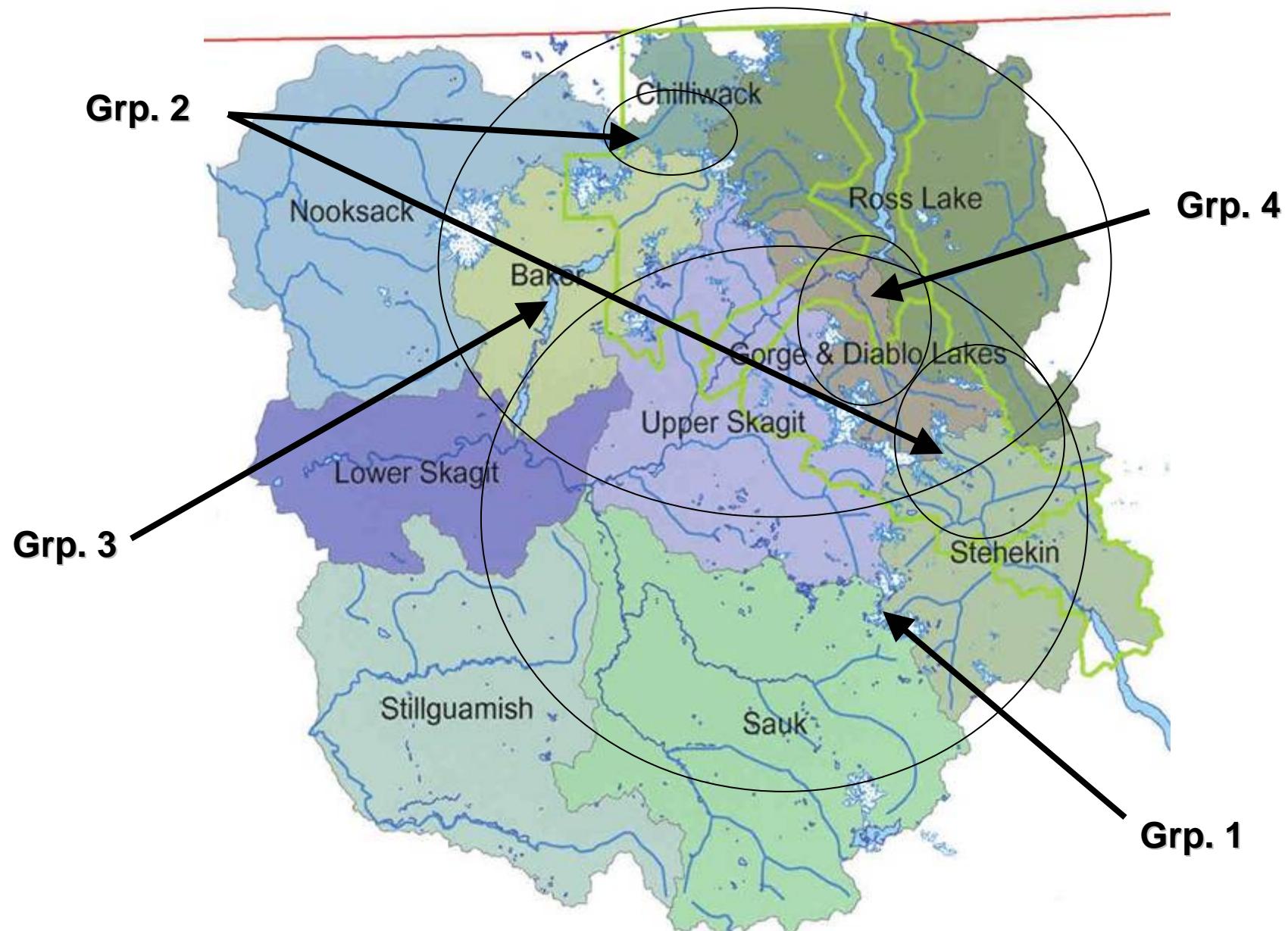
NMDS Ordination by UPGMA Site Groups



Reference Site Taxa

	TAXA (Prob. Of Capture >0.7)	UPGMA Site Groups			
		1	2	3	4
Turbellaria			X	X	
Oligochaeta		X		X	
Acari		X			
<i>Ameletus sp.</i>			X		
<i>Baetis sp.</i>		X	X	X	X
<i>Cinygmulia sp.</i>		X	X	X	
<i>Drunella. coloradensis/flavilinea</i>				X	
<i>Drunella doddsi</i>		X	X	X	X
<i>Epeorus deceptivus</i>		X	X	X	X
<i>Epeorus. grandis</i>		X	X	X	X
<i>Paraleptophlebia sp.</i>		X			
<i>Rhithrogena sp.</i>		X	X	X	X
Capniidae			X		
Chloroperlidae				X	
<i>Isoperla sp.</i>					X
Leuctridae			X		
<i>Megarcys sp.</i>			X	X	X
<i>Sweltsa grp.</i>		X	X	X	
Taeniopterygidae				X	X
<i>Zapada cinctipes</i>				X	
<i>Zapada columbiana</i>		X	X		
<i>Zapada Oregonensis grp.</i>					X
<i>Ecclisomyia sp.</i>			X		
<i>Neothremma sp.</i>			X		
<i>Rhyacophila Betteni grp.</i>		X	X		
<i>Rhyacophila Brunnea/Vemna groups</i>		X	X	X	
<i>Rhyacophila Hyalinata grp.</i>			X		X
Chironomidae		X	X	X	X

Major Watersheds



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Discriminant Function Analysis

- Stepwise Multiple Discriminant Function Analysis (SPSS ver 9.0)
- Functions generated based on linear combinations of predictor variables (env. attributes) that provide the best discrimination between groups (BMI site groups).
- Discriminant scores for each function are computed and used to determine probabilities of group membership.

Discriminant Model Attributes		UPGMA Site Groups			
(untransformed Ref. site data)		1	2	3	4
Longitude		121.2098	121.0356	121.3531	121.1641
Min		120.6299	120.7693	120.9314	121.0156
Max		121.9337	121.4214	121.8167	121.8986
Latitude		48.4669	48.6235	48.7498	48.6397
Min		48.1573	48.4496	48.4111	48.5313
Max		48.9861	48.9657	49.0044	48.9351
% glacial area in catchment		1.2	6.6	4.7	22.6
Min		0.0	1.4	0.0	0.0
Max		7.1	13.9	22.1	50.0
Elevation (m)		521	1084	533	616
Min		110	671	207	158
Max		1189	1561	1042	991
Catchment area (km²)		36.8	21.7	62.6	64.0
Min		2.3	4.9	6.0	9.9
Max		92.5	61.6	178.0	223.7

Other Attributes - days from Jan 01, distance from source, % gradient, annual precipitation, % of catchment in rain-on-snow zone, and conductivity.

Discriminant Functions

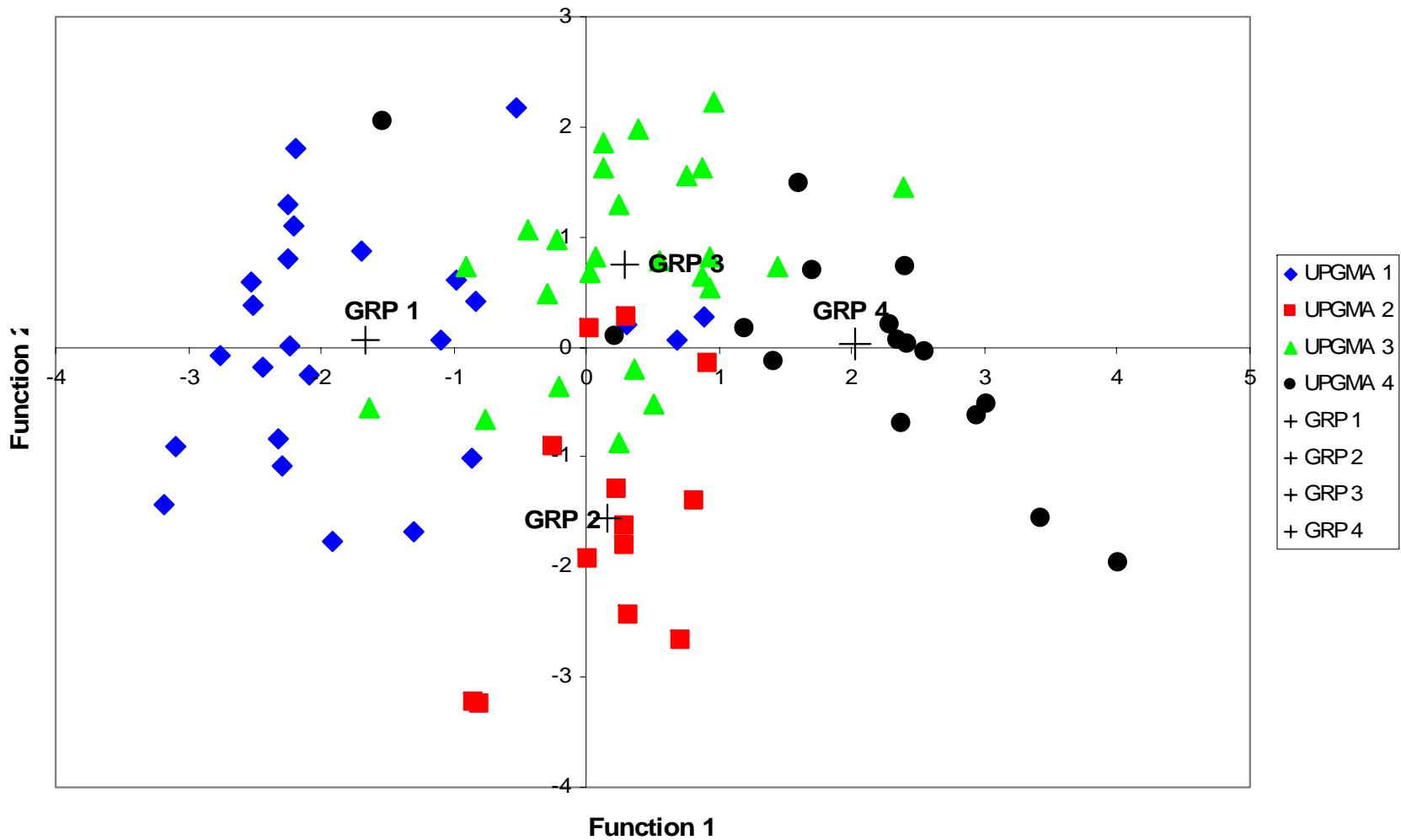
- Model used 3 discriminant functions.**
- 89.7% of the variation explained by functions 1 and 2.**

**Function 1 = 0.685 Longitude + 2.299 Latitude + 0.135 Glacial Area¹
+ 0.027 SQRT Elevation (m) + 0.636 Log10 Watershed Area (km²) -
198.095**

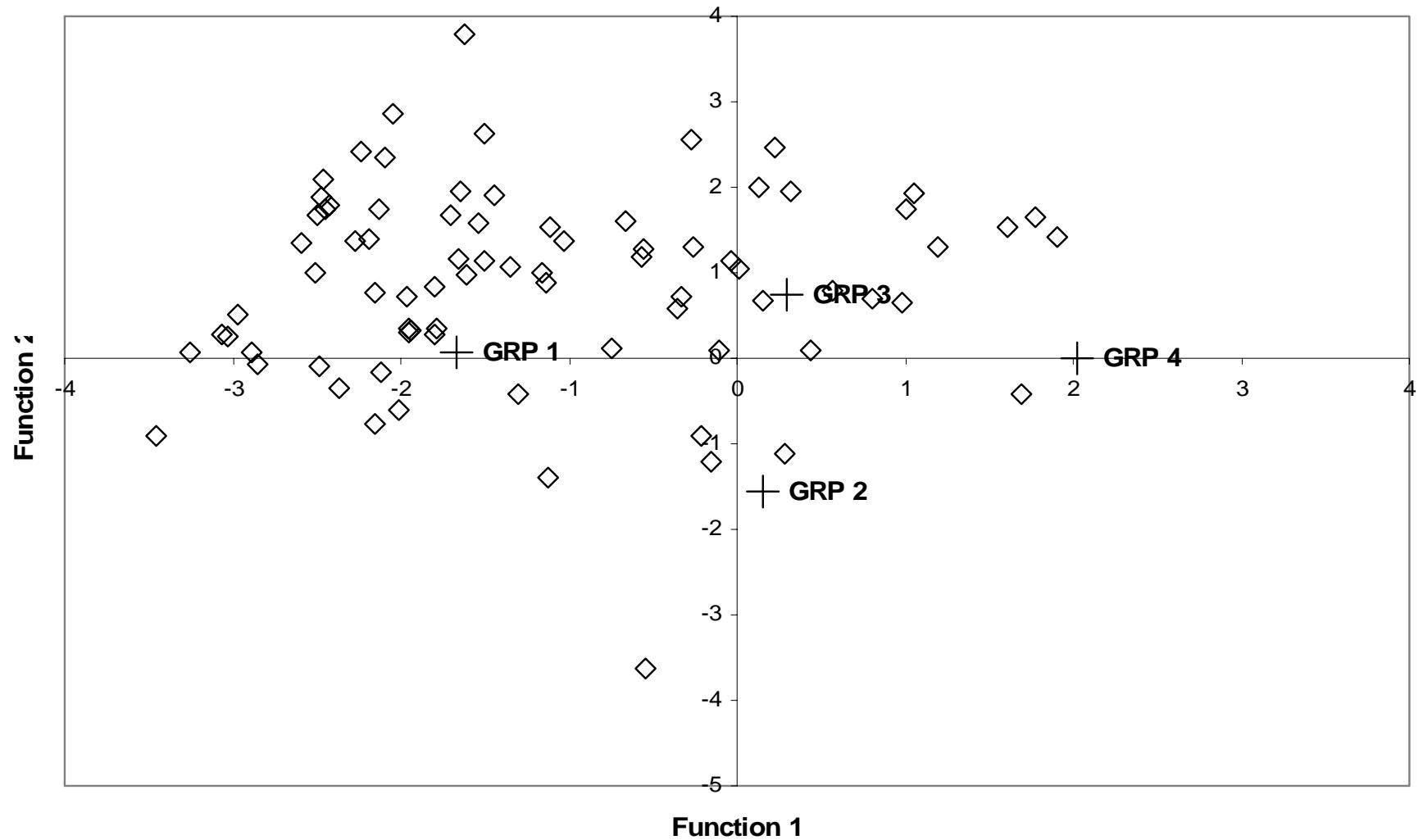
**Function 2 = 1.155 Longitude + 1.141 Latitude – 0.01 Glacial Area¹
- 0.116 Elevation (m) + 1.317 Watershed Area (km²) - 194.530**

¹ Arcsine square root transformation of the % of sample site watershed area with glacial coverage.

Discriminant Function Scores



Discriminant Function Scores for Ungrouped Cases



Classification results

UPGMA Site Grp:	% Correctly Classified				
	1	2	3	4	% Overall
Original (n=79)	72.0	76.9	84.0	75.0	77.2
Cross-validated (n=79)	72.0	69.2	76.0	75.0	73.4

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O/E Calculation

Step 1.
DFA OUTPUT

Sample Site	UPGMA4	Pred. grp	Grp1prob	Grp2prob	Grp3prob	Grp4prob
BEBA01	3	3	0.05469	0.00934	0.90464	0.03133
BISA01	1	1	0.96372	0.00057	0.03563	0.00008
BRSTNF	2	2	0.26967	0.45236	0.24562	0.03235
BUSA01	1	1	0.92453	0.00287	0.07199	0.00062

**Reference Grp.
Taxon Frequency**

Step 2.

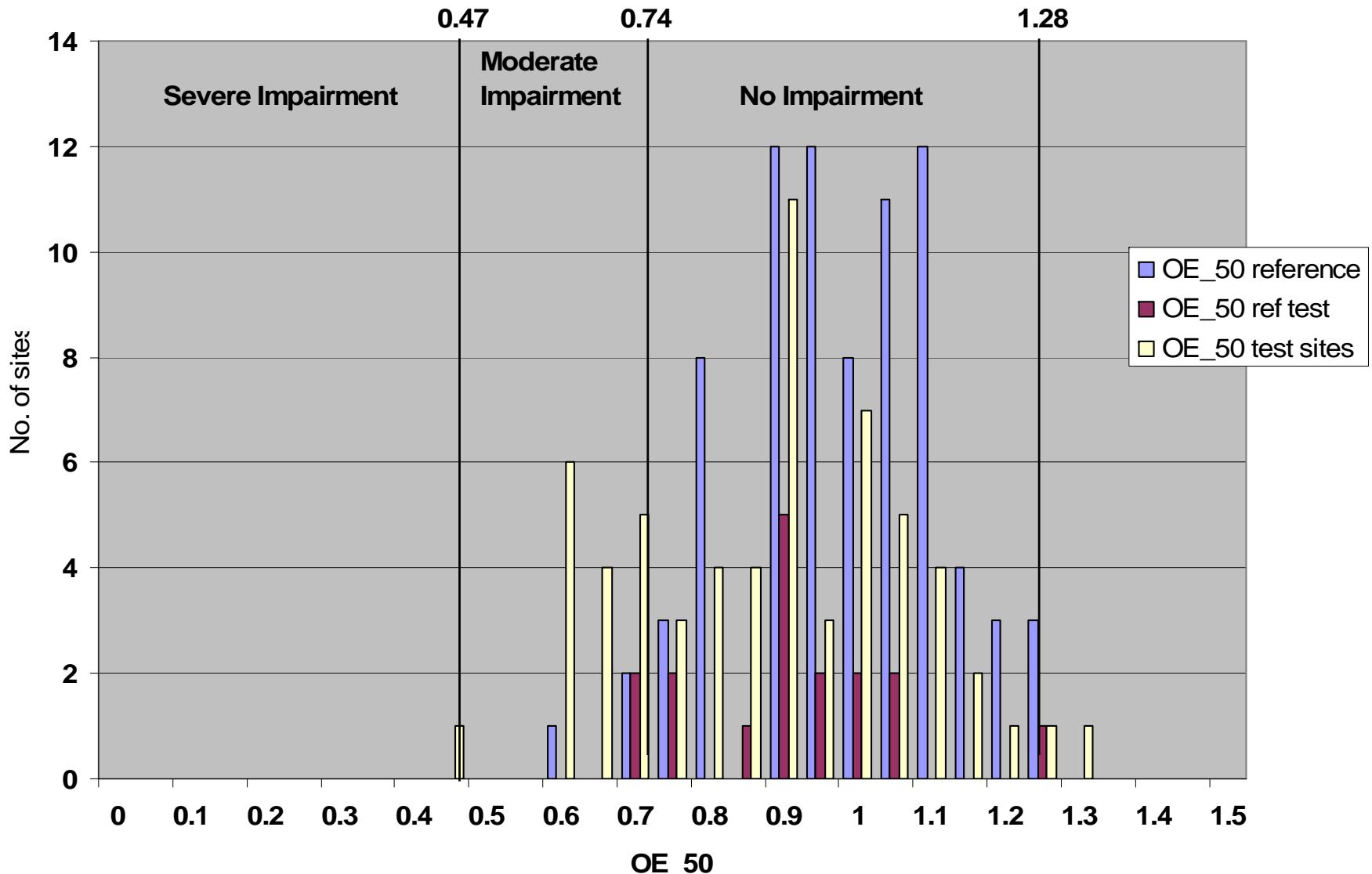
EPEOGR	PARALE	CAUDSP	VISOKA
0.760	0.760	0.520	0.640
0.923	0.615	0.692	0.692
0.760	0.400	0.280	0.400
1.000	0.000	0.625	0.250

Sample Site	UPGMA4	Step 4. E_{50}	Step 5. $Obs \geq .5$	Step 6. O/E_{50}	Step 3. Overall Prob. Of Capture	Overall Prob. Of Capture	Overall Prob. Of Capture	Overall Prob. Of Capture
BEBA01	3	16.39	19	1.159	0.769	0.409	0.308	0.404
BISA01	1	21.32	18	0.844	0.760	0.747	0.512	0.443
BRSTNF	2	21.38	23	1.076	0.842	0.582	0.542	0.411
BUSA01	1	21.23	22	1.036	0.761	0.733	0.503	0.631

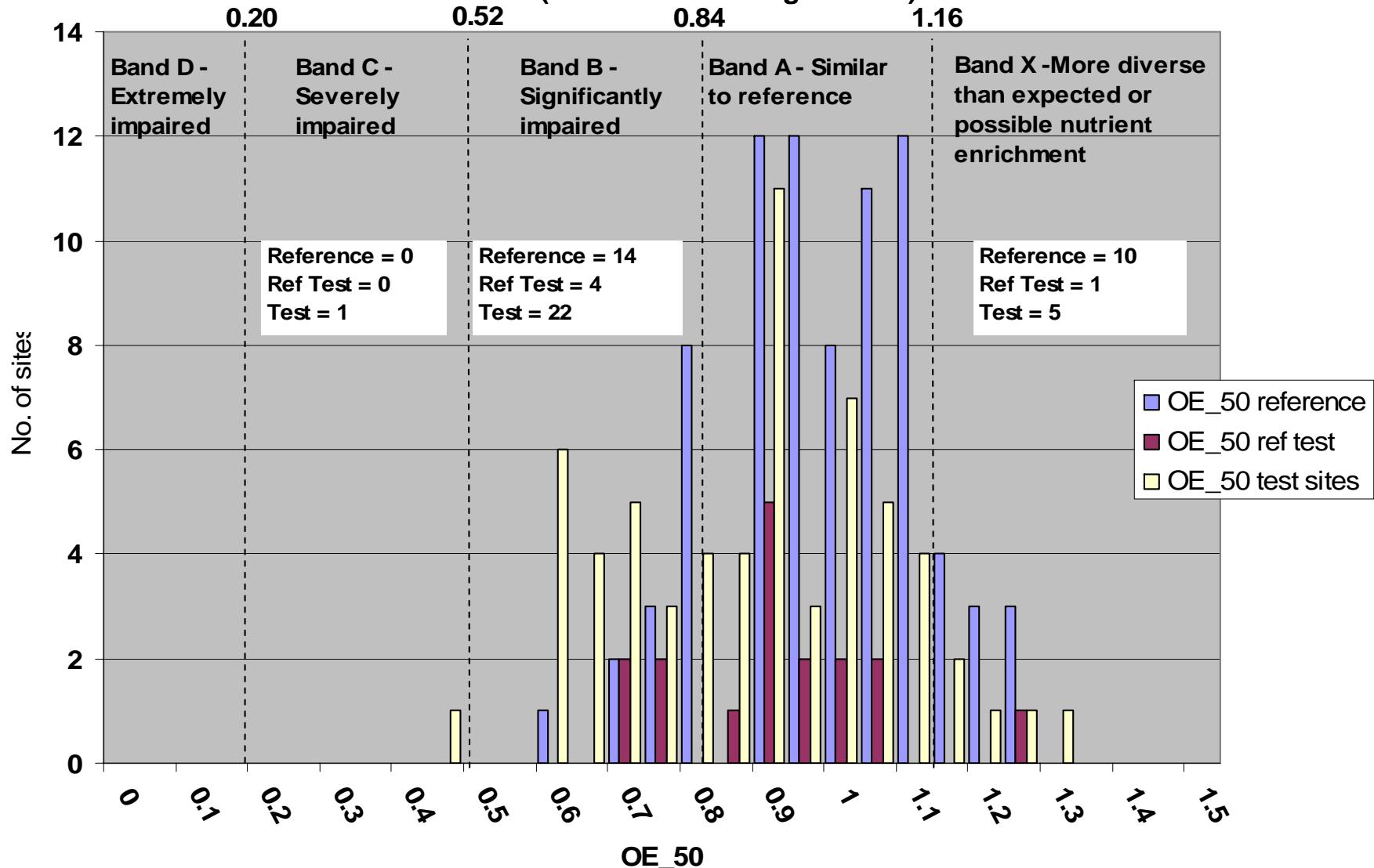
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Frequency distribution of reference and test site scores



Frequency distribution of reference and test site scores
(AUSRIVAS Banding Scheme)



O/E AND NCIBI COMPARISON

- Precision and Accuracy**
- Relation to Disturbance Gradient**
- Agreement between methods**

Precision

(designation of replicates at each site as all unimpaired or all impaired)

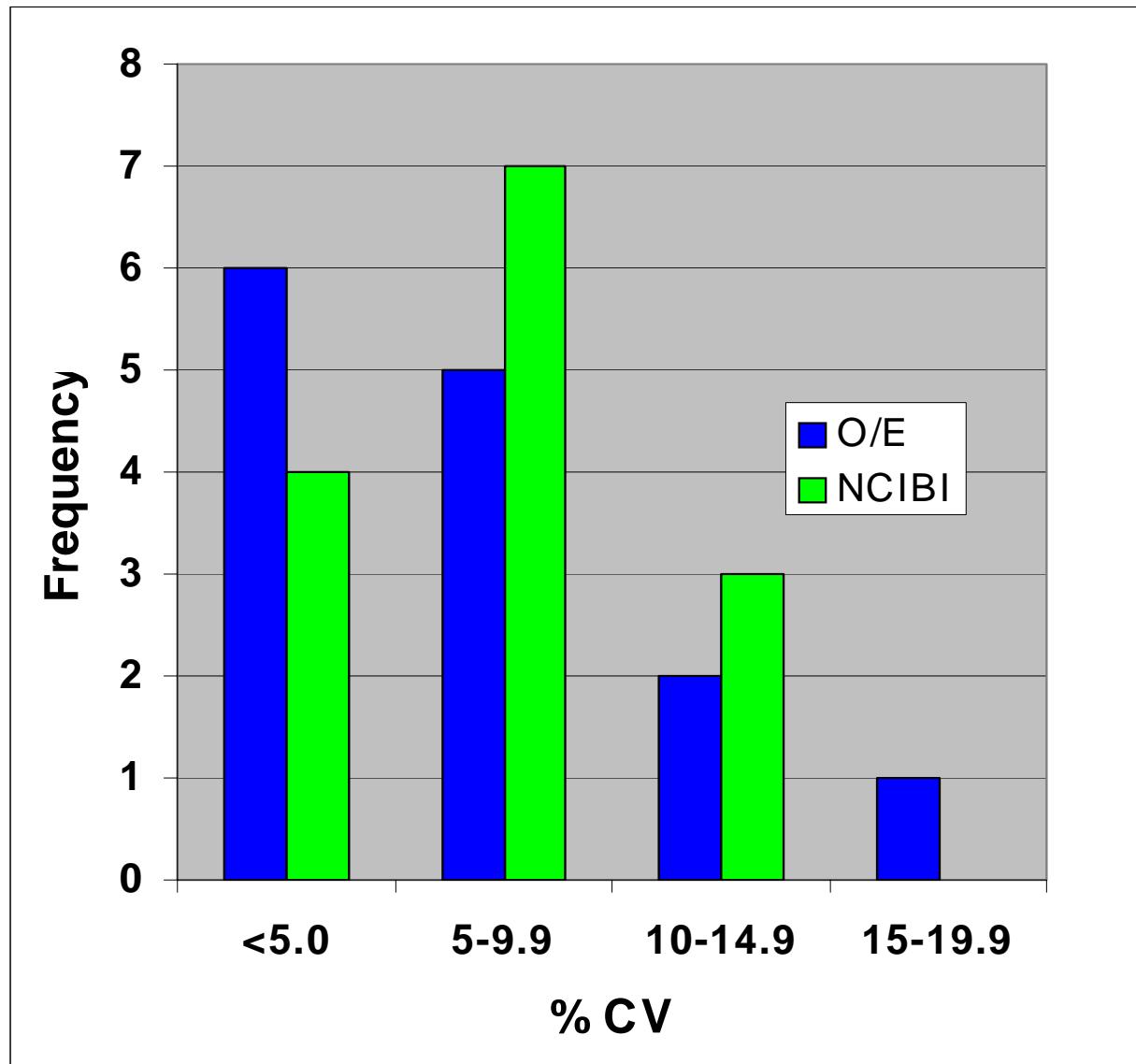
Assessment method	Agreement between replicates	
	Within site (n= 14sites, 3 reps)	Between year (26sites, 2 reps)
O/E ₅₀ (+/- 2 STDEV)	79%	85%
O/E ₅₀ (AUSRIVAS)	71%	38%
NCIBI	79%	89%

Accuracy

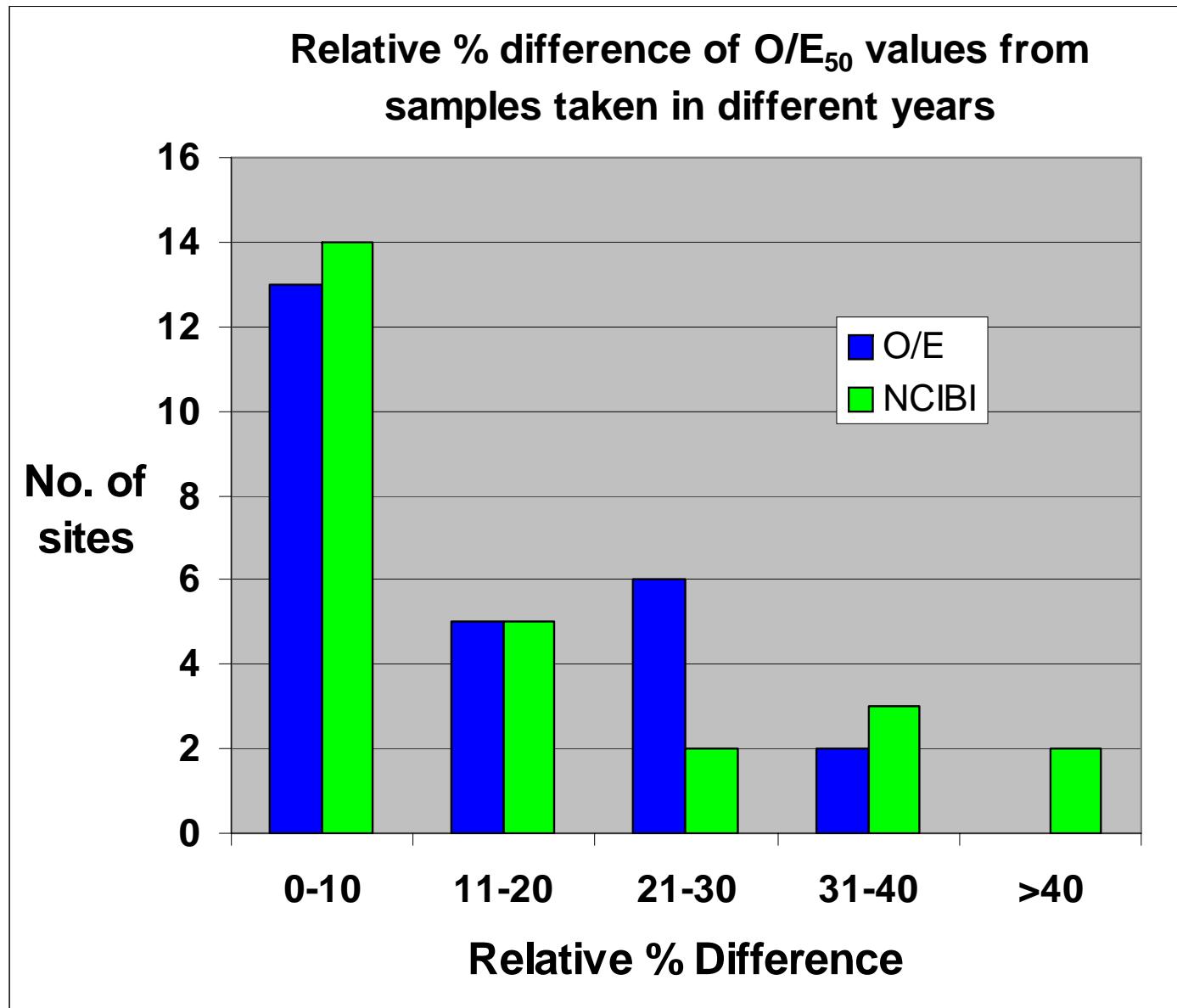
(analysis of reference sites not used in IBI or O/E development)

Assessment method	Reference test sites designated as unimpaired
O/E ₅₀ (+/- 2 STDEV) (n=17)	88%
O/E ₅₀ (AUSRIVAS) (n=17)	82%
NCIBI (n=24)	79%

Within Site Replication



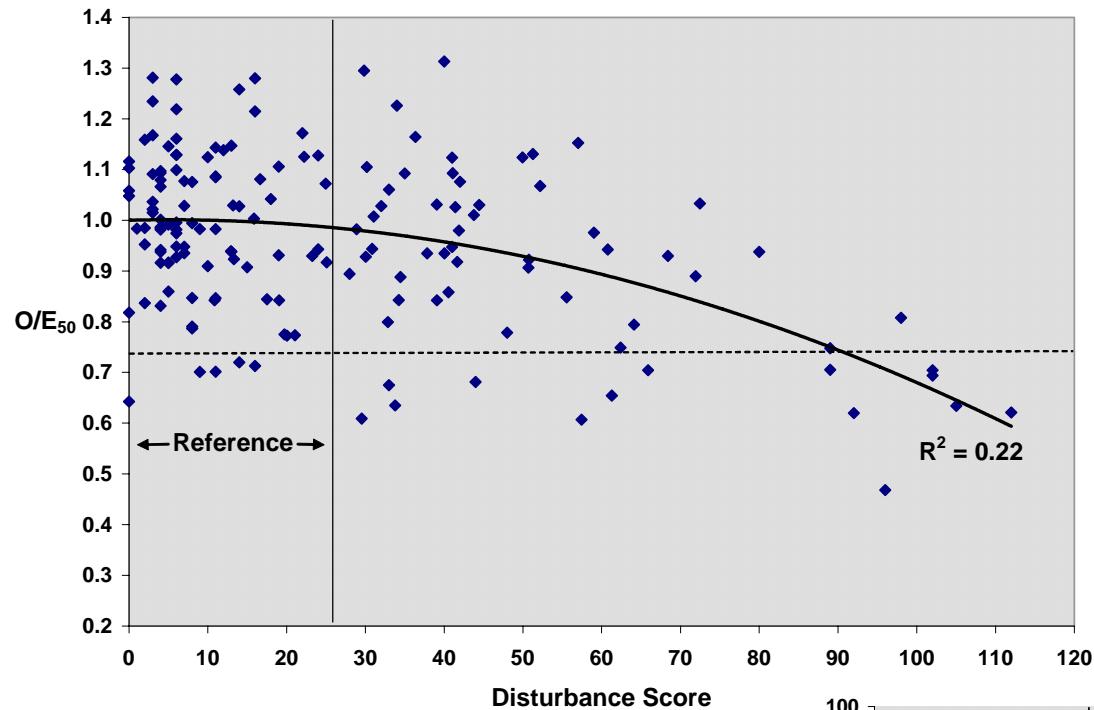
Between Year Replication



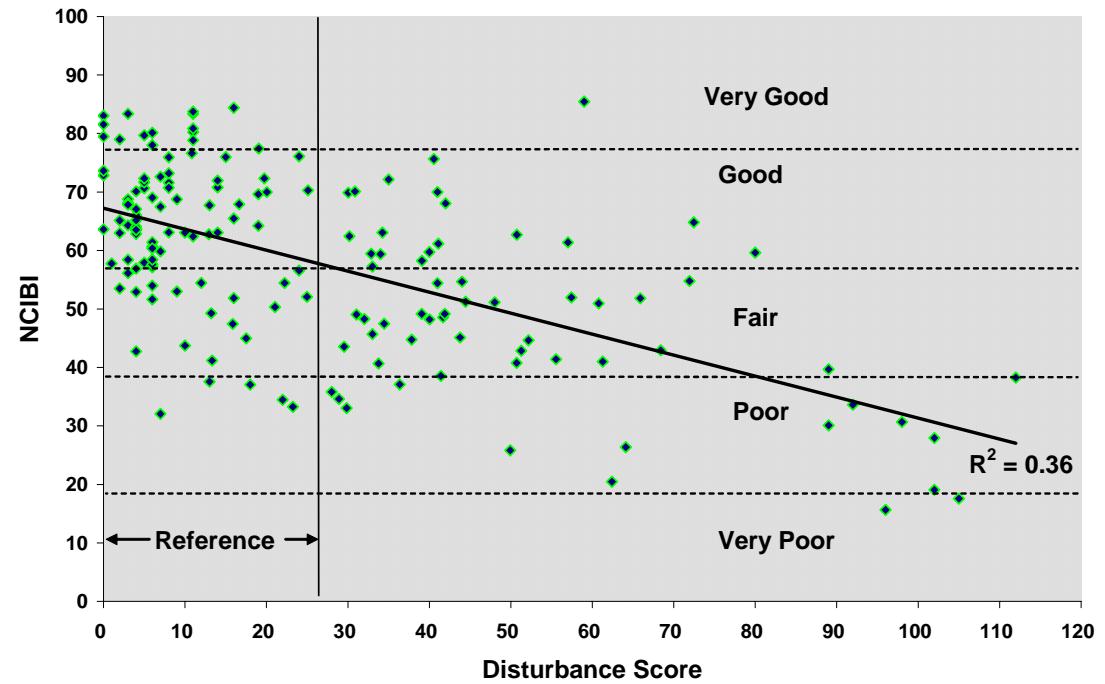
O/E and Metric Correlation (158 sites and 70 metrics)

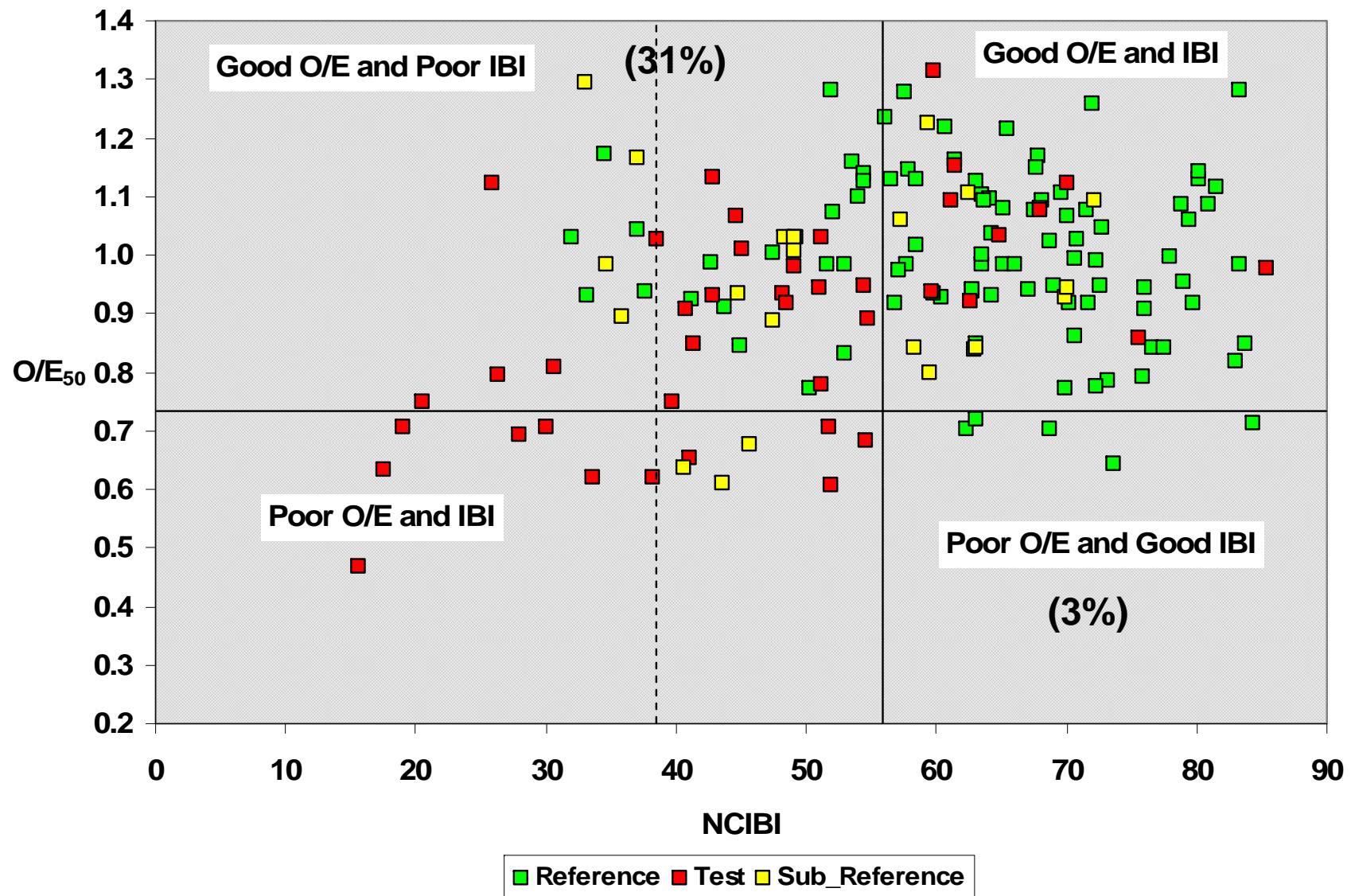
Metric	Correlation (p<0.01)
Intolerant Richness*	0.59
EPT Richness	0.53
Plecoptera Richness	0.48
Insect Richness	0.38
Margalef Index	0.37
Total Richness	0.37
Heptagenia Richness	0.36
Plecoptera Shredder Richness	0.36
Predator Richness	0.34
Trichoptera Richness	0.34

* included in NCIBI



O/E₅₀ by Disturbance Score





Conclusions

- NCIBI and O/E represent different characteristics of the BMI communities.
- Both NCIBI and O/E had acceptable levels of precision (*within sites and between years*) and accuracy (*designation of reference test sites as unimpaired*).
- NCIBI appears to do a better job of following the disturbance gradient. ?
- There is some uncertainty about intermediate levels of the disturbance gradient.

Recommendations

- Continue to refine O/E and NCIBI indices**
 - Assess the need for IBI stratification.
 - Use more site groups for O/E method
 - More detailed examination of sites with intermediate disturbance scores.
- Use both approaches for future monitoring.**
- Examine other methods for detection of change**
 - O/E Signal Score (AusRivAS)
 - RIVPAC Q14 (Wright, Furse *et al.* 1995) abundance based model.
 - Environmental filters (Chessman 2004).